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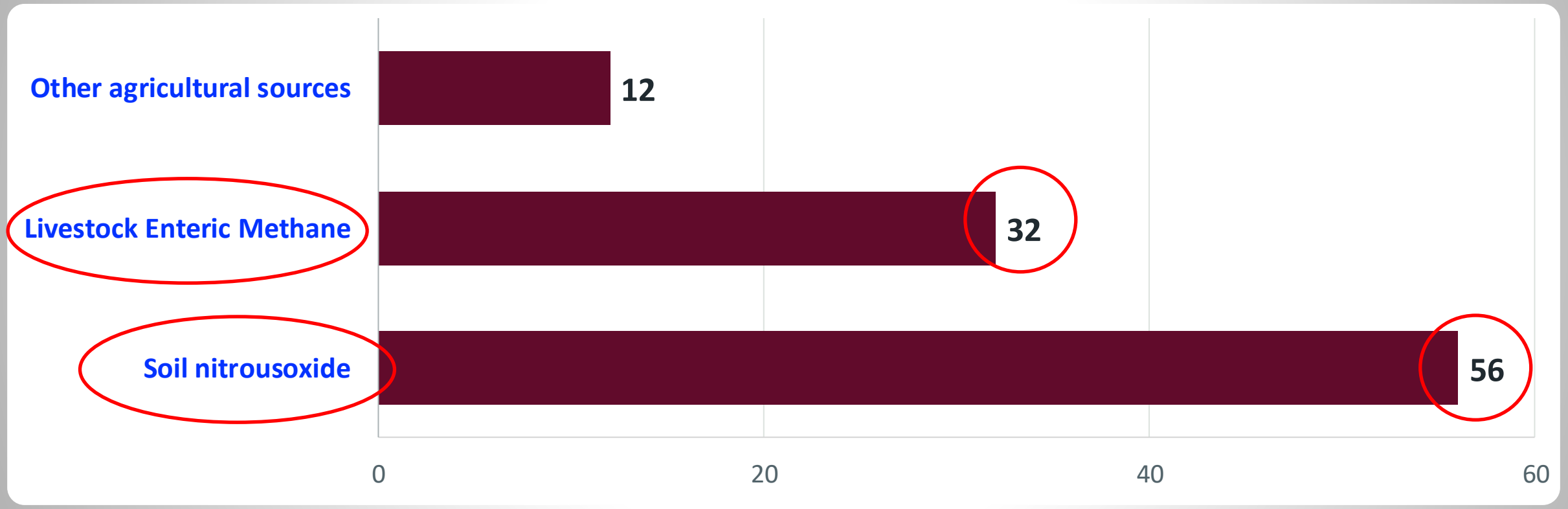
Agricultural Sector Emissions and Reduction Strategies

What We Know and What We're Missing

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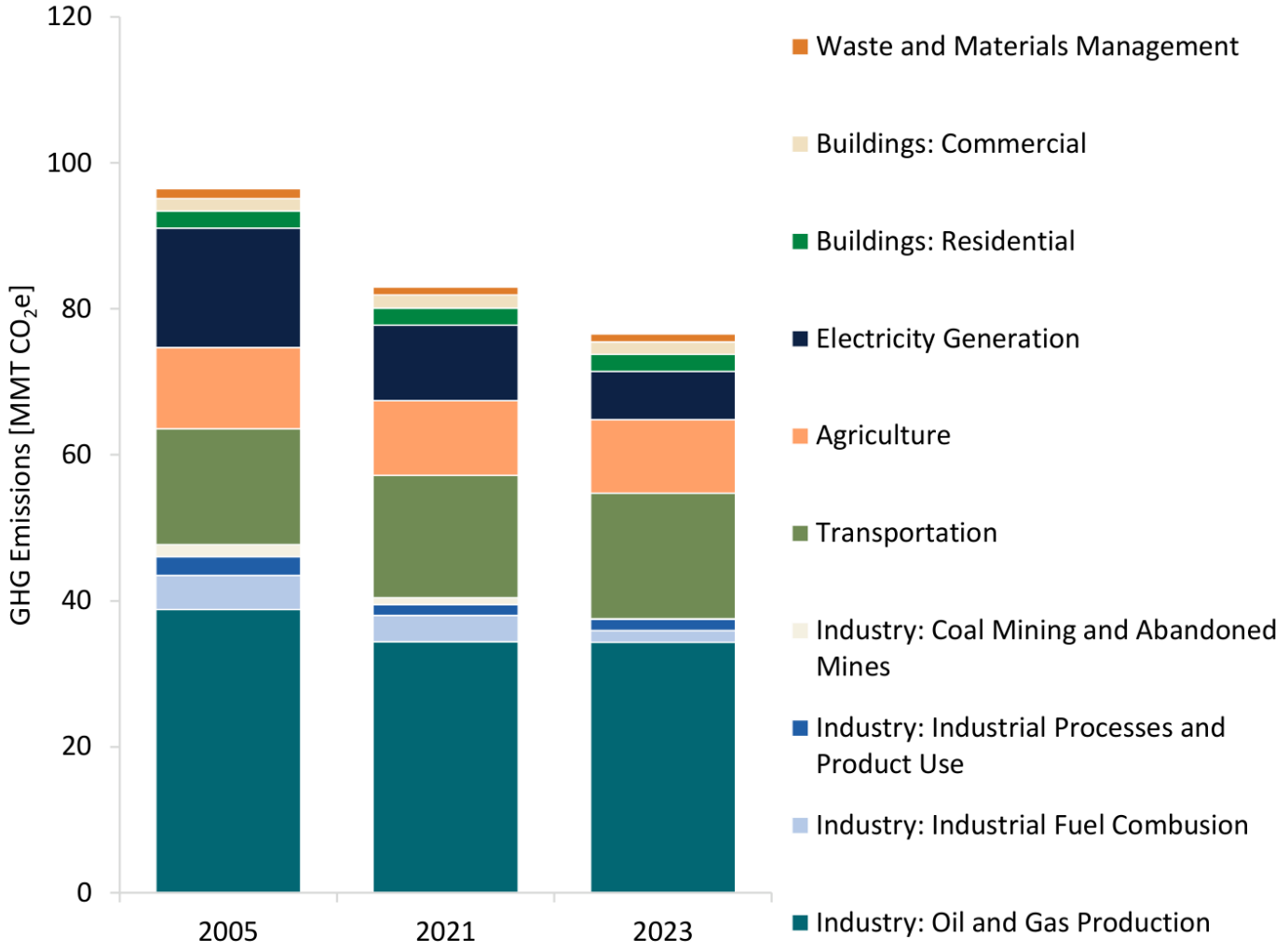
The state estimate identifies two main agricultural sources

Shares of estimated agricultural emissions in 2023 (%)



[1] NMED / ERG (2026), Tables 2–3; Fig. 3

NMED reports lower absolute agricultural emissions



Agriculture

11.15 → 10.07

million metric tons CO_2e

About 10% lower

All sectors: 96.44 → 76.54
About 21% lower

[1] NMED / ERG (2026), Tables 2–3; Fig. 3

Agriculture has made great progress!

Increases in production efficiency have helped reduce emissions

(especially per unit of product - called Intensity)

–10%

NM agricultural emissions reduction from 2005–2023

NM agricultural emissions have decreased by **10%** in the NMED GHG Emissions Inventory data.

More C to Milk and Meat means less C to CH_4

More food per unit of input = Efficiency = SUSTAINABILITY

Better breeding, feeding, and crop management have reduced the resources needed per pound of product produced

Who pays?

Are all improvements on the back of producers – even if there is no gain other than GHG?

NRCS Programs (EQIP) and qualifying Carbon Credits (CTFS) **may** help.

Challenge: scale (fitting scale of NRCS programs to scale of Industry)

[1] NMED / ERG (2026), Tables 2–3; Fig. 3

[8] USDA ERS, Nutrient Management, 1996–2010 chart

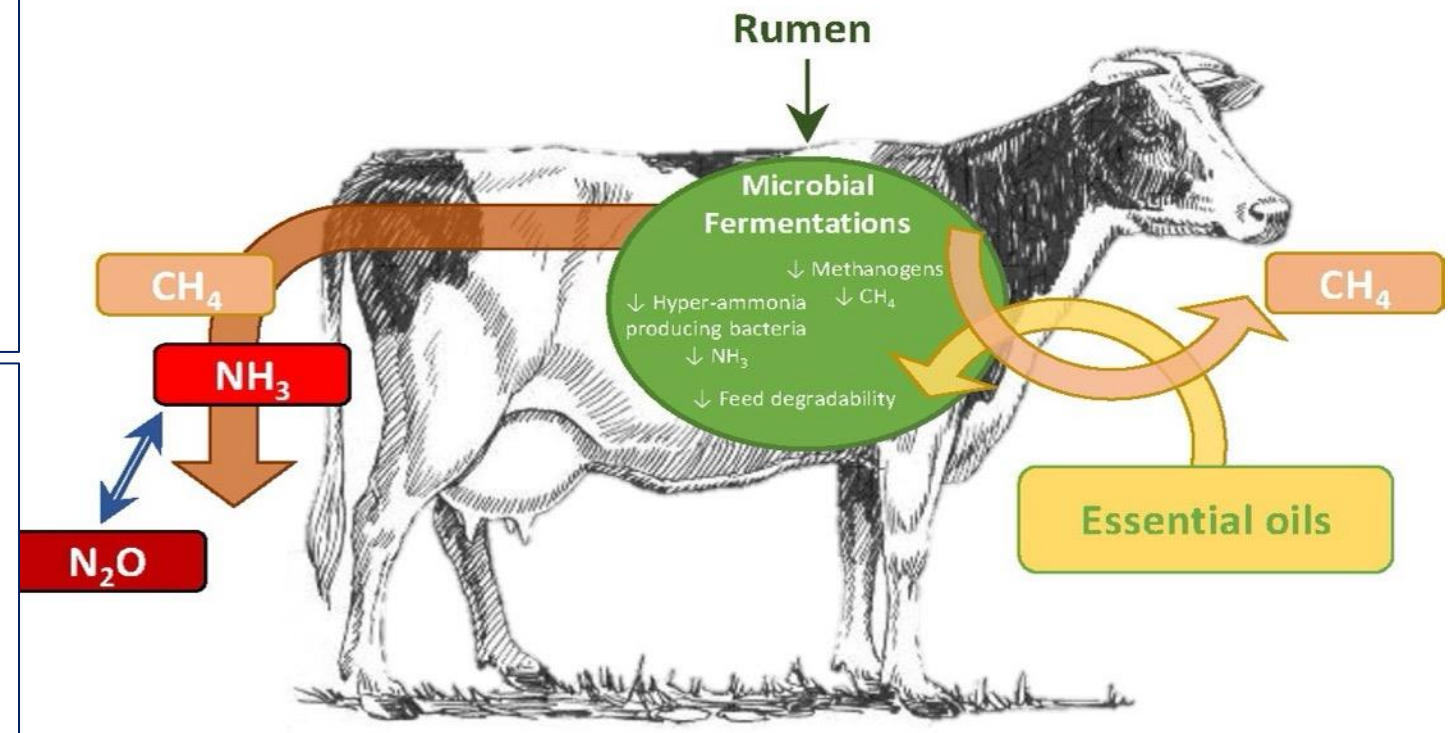
[5] Capper & Cady (2020), doi:10.1093/jas/skz291

What is enteric methane?

Cows naturally consume fibrous materials – indigestible to monogastrics – chew and chew while making cellular content (sugars=energy) available to the ruminal microbes (bacteria, protozoa) so that they can build microbial protein which the cow uses to grow (make meat) and make milk when lactating.

In that natural process cows produce byproducts such as CO_2, CH_4 and NH_3/NH_4^+ which can oxidize to N_2O.

These gasses are called Greenhouse Gasses (GHG) which are implicated in changing the climate.

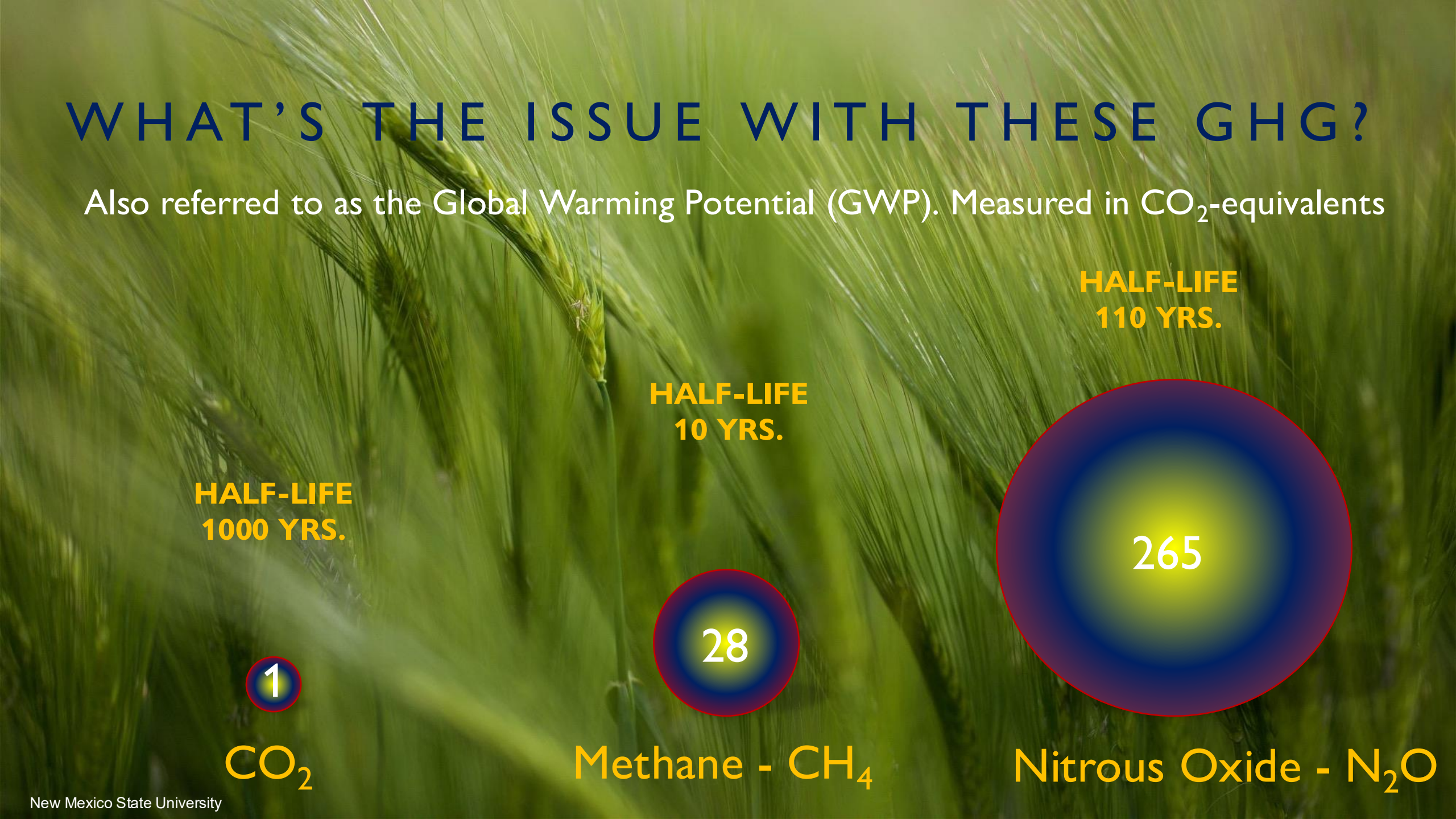


Note: more Carbon from feed going to Meat & Milk means less goes to Manure.

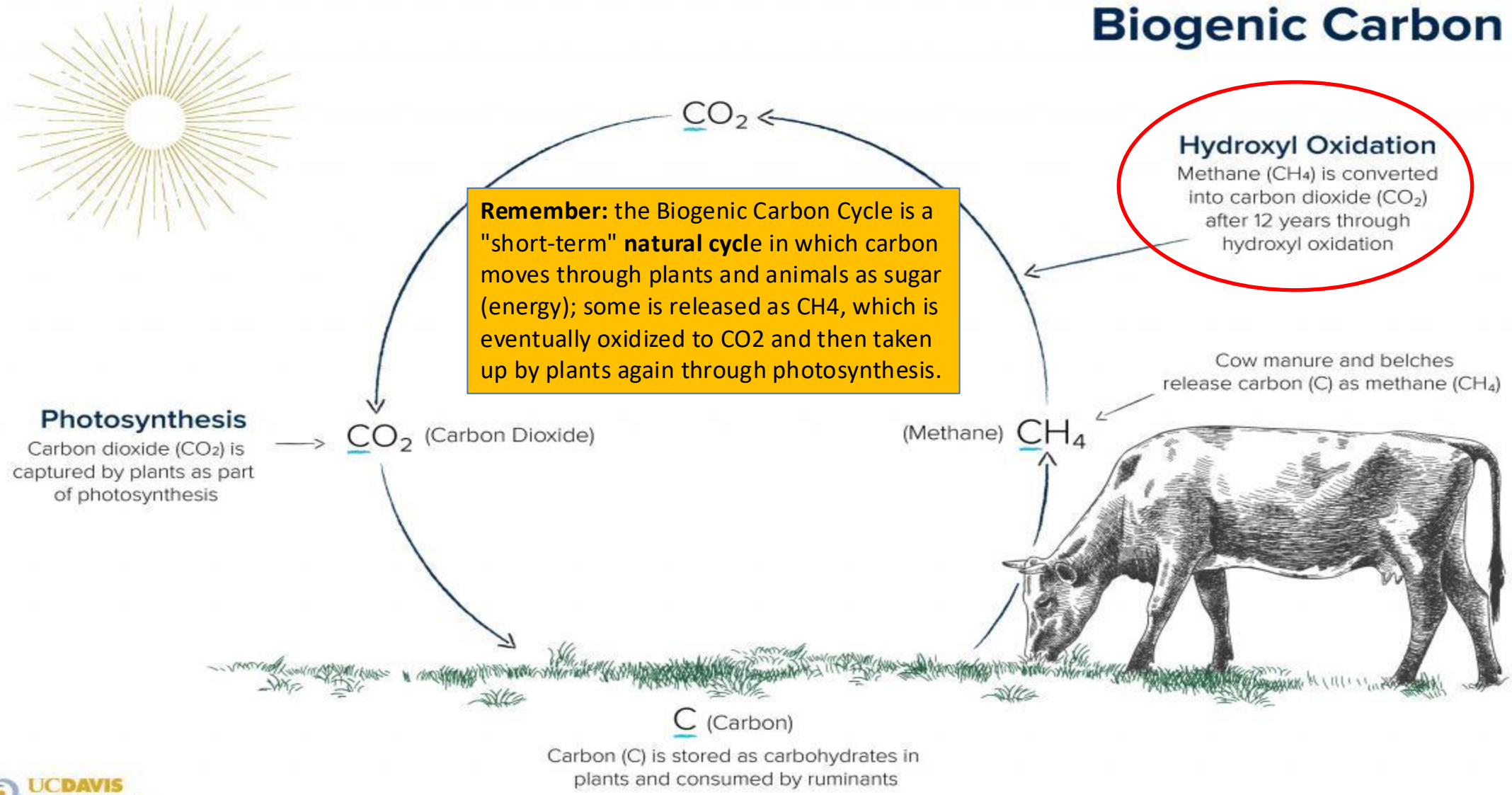
This is doing more with less, also referred to as increased efficiency or increased sustainability!

WHAT'S THE ISSUE WITH THESE GHG?

Also referred to as the Global Warming Potential (GWP). Measured in CO_2-equivalents

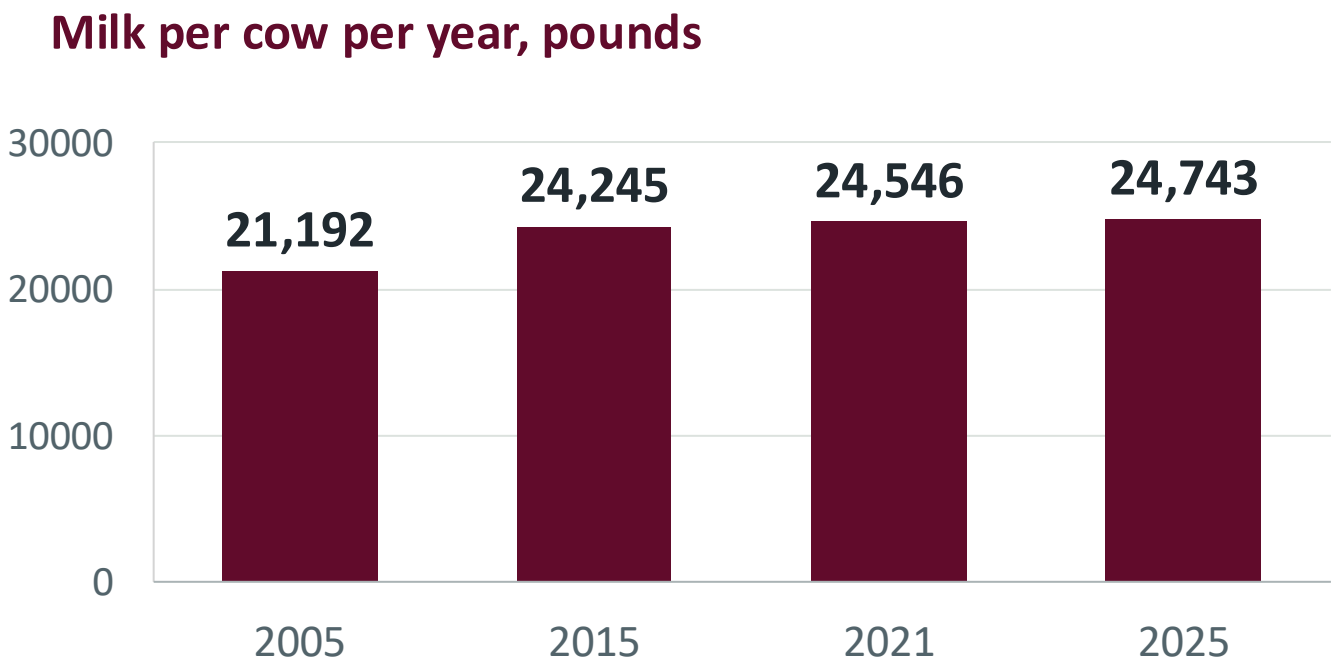


Biogenic Carbon Cycle



UCDAVIS CLEAR Center

NM livestock: more milk per cow



16.8% more per cow

230,000 milk cows
430,000 beef cows

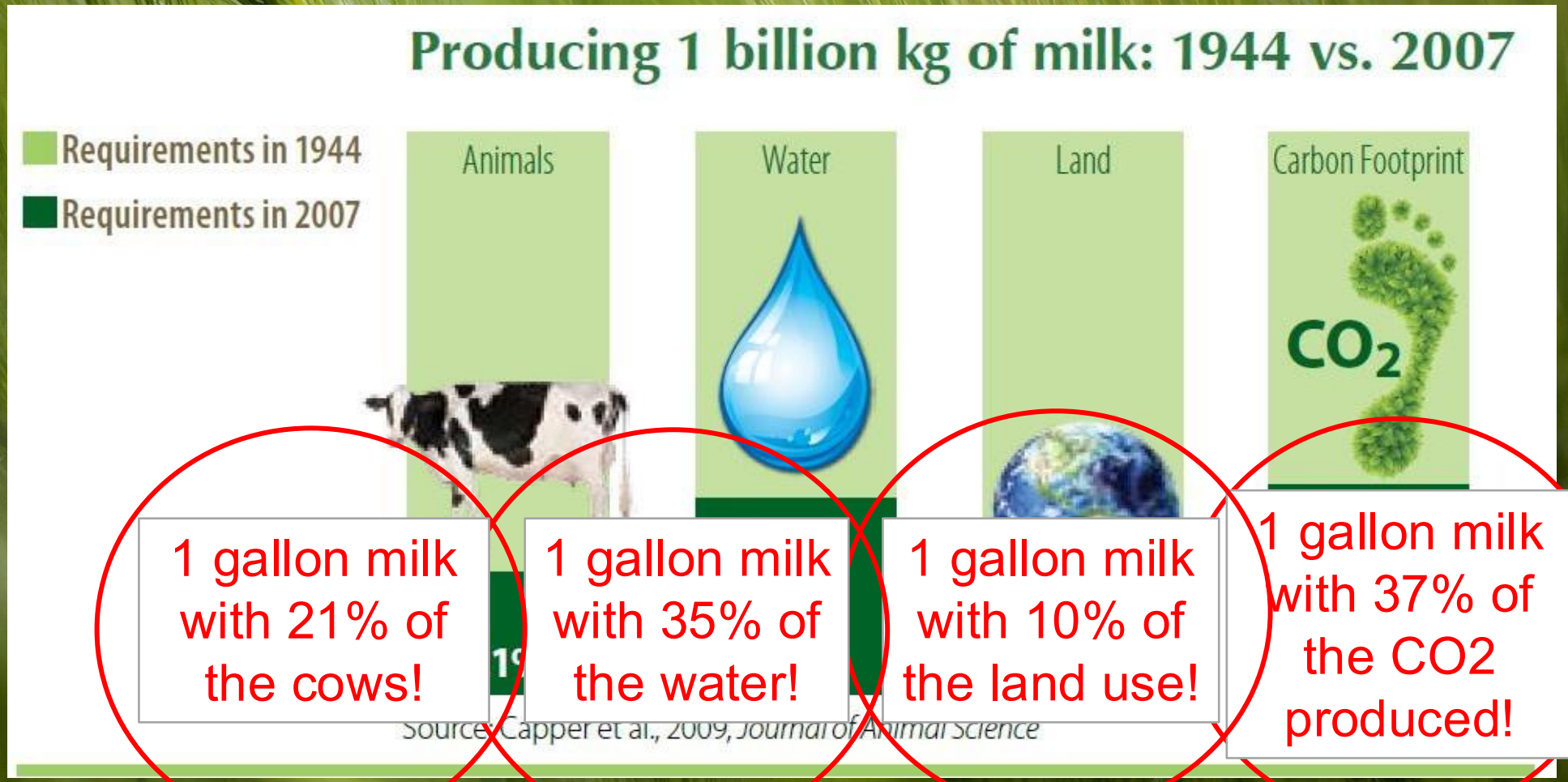
January 1, 2026

Total NM milk output fell about 25% in 2021–2025. Lower total production is also part of the emissions picture.

[3] USDA NASS, NM bulletins (2006, 2025)

[4] USDA NASS, 2025 NM overview (2026 inventory)

TIMELINE: 1944 – 2007 – FIRST DAIRY LCA



Source: US Innovation Center for US Dairy, 2013

Fifty years of environmental progress for United States dairy farms

Analyzes historical shifts in management, technology, and environmental footprints across US dairy operations from 1971 to 2020

Production Efficiency

- **Milk yield exploded: Milk production per cow increased by 142%** (a 2.4-fold increase) over the 50-year period.
- **Fewer cows needed:** The total US dairy herd shrunk by 22%, dropping from 11.8 million cows in 1971 to 9.2 million cows in 2020.
- **Surging national supply:** Total US milk production grew by 88% overall, driven entirely by individual cow efficiency.

Environmental Impact Per Kilogram of Milk (Intensity)

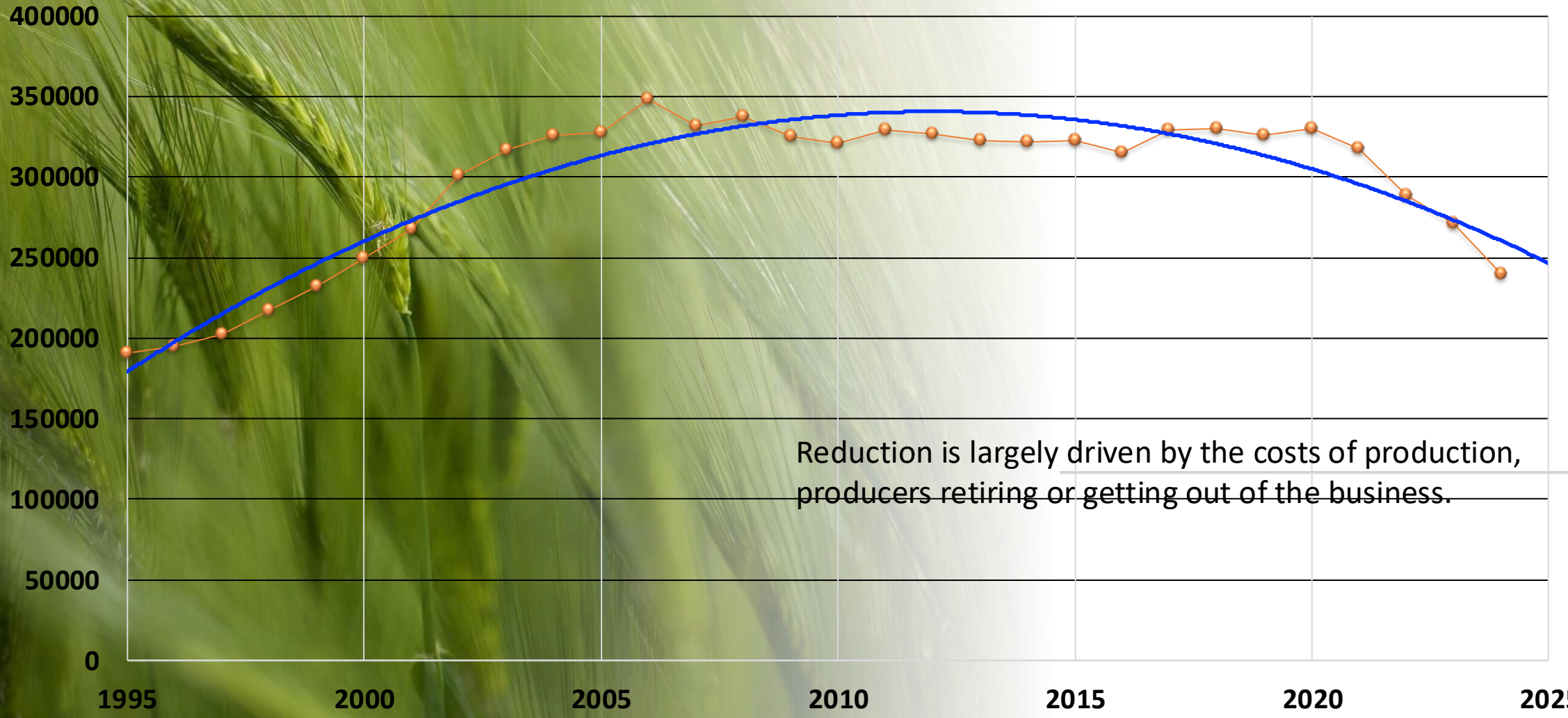
- **Carbon footprint down: Greenhouse gas (GHG) intensity decreased by 38%** per unit of energy-corrected milk.
- **Water conservation:** Fossil water use intensity dropped by 44%.
- **Land footprint reduced:** Total land use intensity decreased by 49%.
- **Nutrient efficiency:** Nitrogen and phosphorus loss intensities dropped by 38% and 42%, respectively.
- **Energy savings:** Nonrenewable energy use intensity decreased by 13%.

JDS 2024 https://doi.org/10.3168/jds.2023-24185

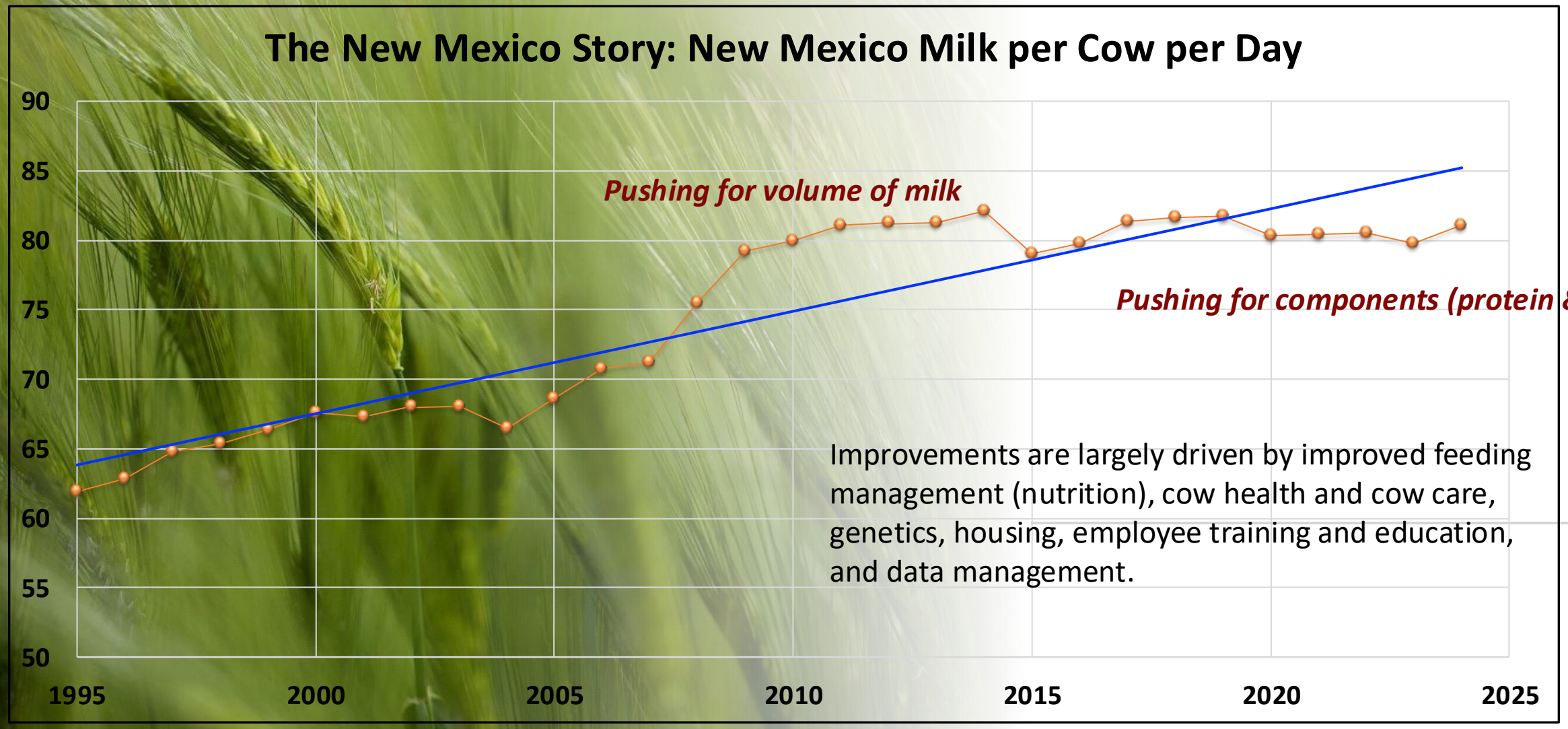
What about New Mexico specifically?



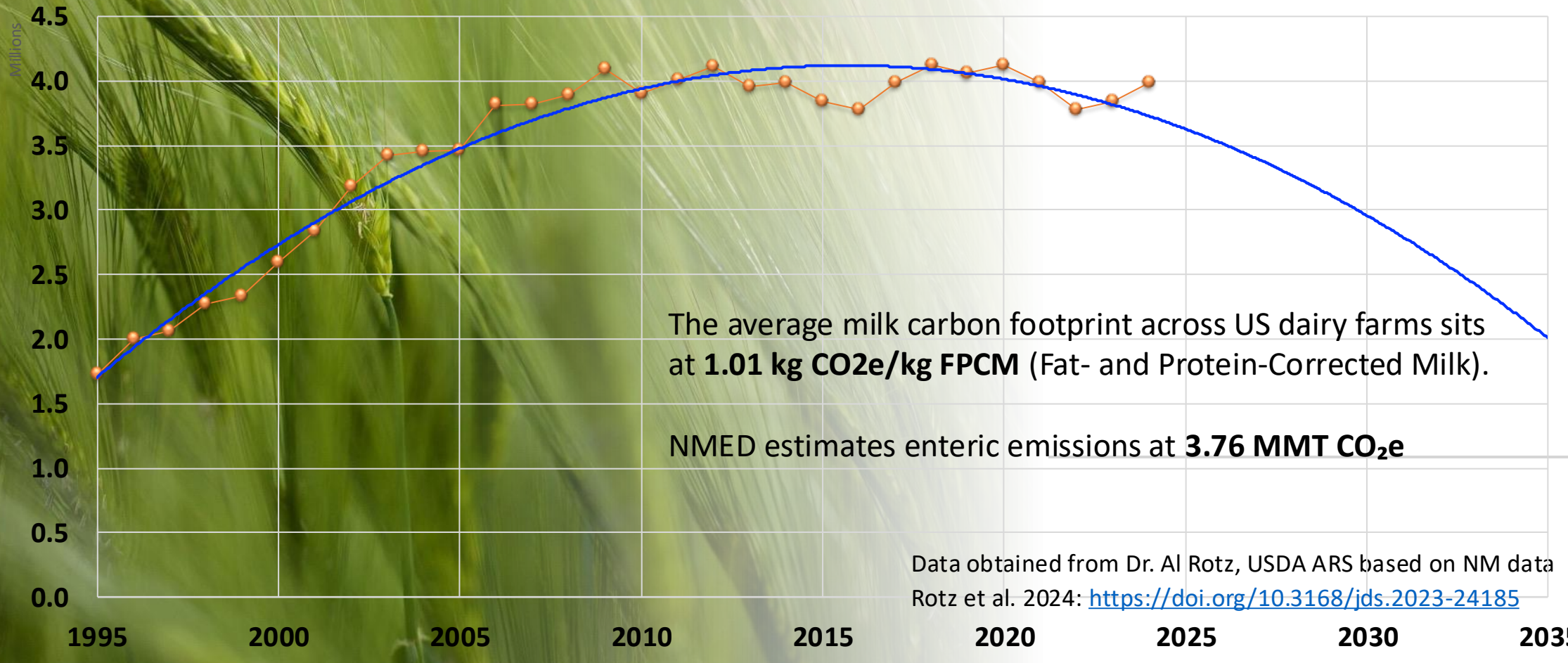
The New Mexico Story: New Mexico Number of Dairy Cows



Reduction is largely driven by the costs of production, producers retiring or getting out of the business.


The New Mexico Story: New Mexico Milk per Cow per Day
90
85
80
75
70
65
60
55
50
1995
2000
2005
2010
2015
2020
2025
Pushing for volume of milk
Pushing for components (protein & fat)
Improvements are largely driven by improved feeding management (nutrition), cow health and cow care, genetics, housing, employee training and education, and data management.

NM estimated GHG emissions - MMT CO2e

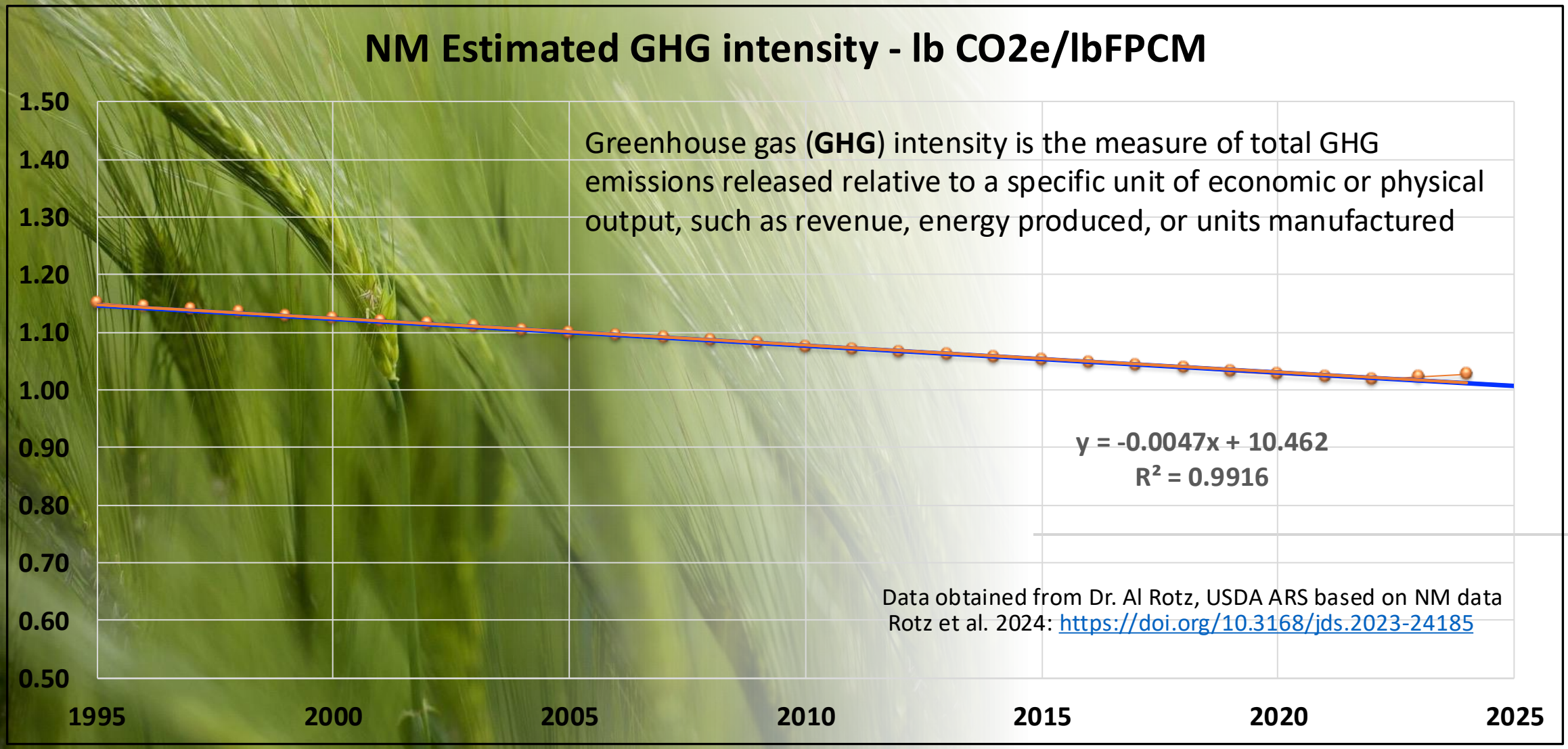


The average milk carbon footprint across US dairy farms sits at **1.01 kg CO2e/kg FPCM** (Fat- and Protein-Corrected Milk).

NMED estimates enteric emissions at **3.76 MMT CO_2e**

Data obtained from Dr. Al Rotz, USDA ARS based on NM data
Rotz et al. 2024: https://doi.org/10.3168/jds.2023-24185

NM Estimated GHG intensity - lb CO2e/lbFPCM



Mitigation Strategies and GHG Avoidance Potential for New Mexico Agriculture



SOIL: Recognized management practices to reduce GHG emissions

Cropping and Soil Sequestration Potential

SOUTHWEST SOIL CARBON SEQUESTRATION POTENTIAL

CONSERVATION
(No-Till/**TILLAGE** Reduced)

Arid/Semi-Arid Croplands



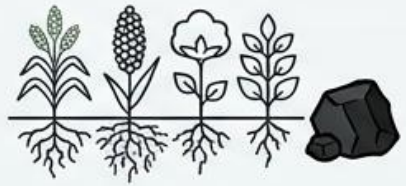
(No-Till/Disrupt)

10-18% SOC Increase

1.5-3.0 MMT CO_2e/year

COVER CROPS & BIOCHAR

Sorghum/Cotton & Pecan Residues



0.4-0.8 MT CO_2e/acre/year

2.0-4.5 MMT CO_2e/year

MANAGED RANGELANDS

Multi-Paddock / Adaptive Grazing



65% of Regional Land Area

8.0-15.0 MMT CO_2e/year

TEXAS A&M: Blackland Research

NMSU: Arid Land Sequestration Studies

USDA SOUTHWEST: Climate Hubs Data

Soil: recognized management practices to reduce GHG emissions

Conservation Tillage (Reduced or No-Tillage)

CARBON SEQUESTRATION POTENTIAL OF CONSERVATION TILLAGE

Focus: New Mexico & Texas (The US Southwest)

Reduced Tillage



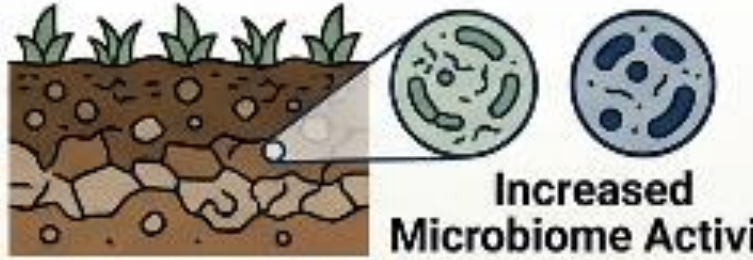
1.5 – 3.0

MMT CO_2e / YEAR

TOTAL REGIONAL POTENTIAL

Direct Link to Reduced Disturbance

Increased Microbiome Activity



10% – 18%

INCREASE IN SOIL SOIL ORGANIC CARBON (SOC)

Key Climate Strategy for Arid & Semi-Arid Ecosystems

GLOBAL RESEARCH ALLIANCE: Evaluation Report (Arid Soils)

TEXAS A&M AG RENEWABLE: Blackland Research

NMSU: Arid Land Studies

Soil: recognized management practices to reduce GHG emissions

Nutrient Stewardship Potential

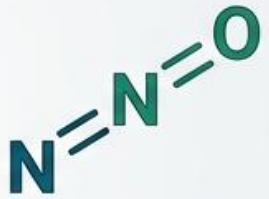
NUTRIENT STEWARDSHIP POTENTIAL

REDUCED APPLICATION RATE



3.0 - 5.5 MMT CO_2e/year
TOTAL REGIONAL POTENTIAL

NITROUS OXIDE EMISSONS AVOIDED
EMISSIONS AVOIDED



25% - 40% N_2O
REDUCTION CAPACITY

Key Climate Strategy for Southwest Croplands (TX & NM)

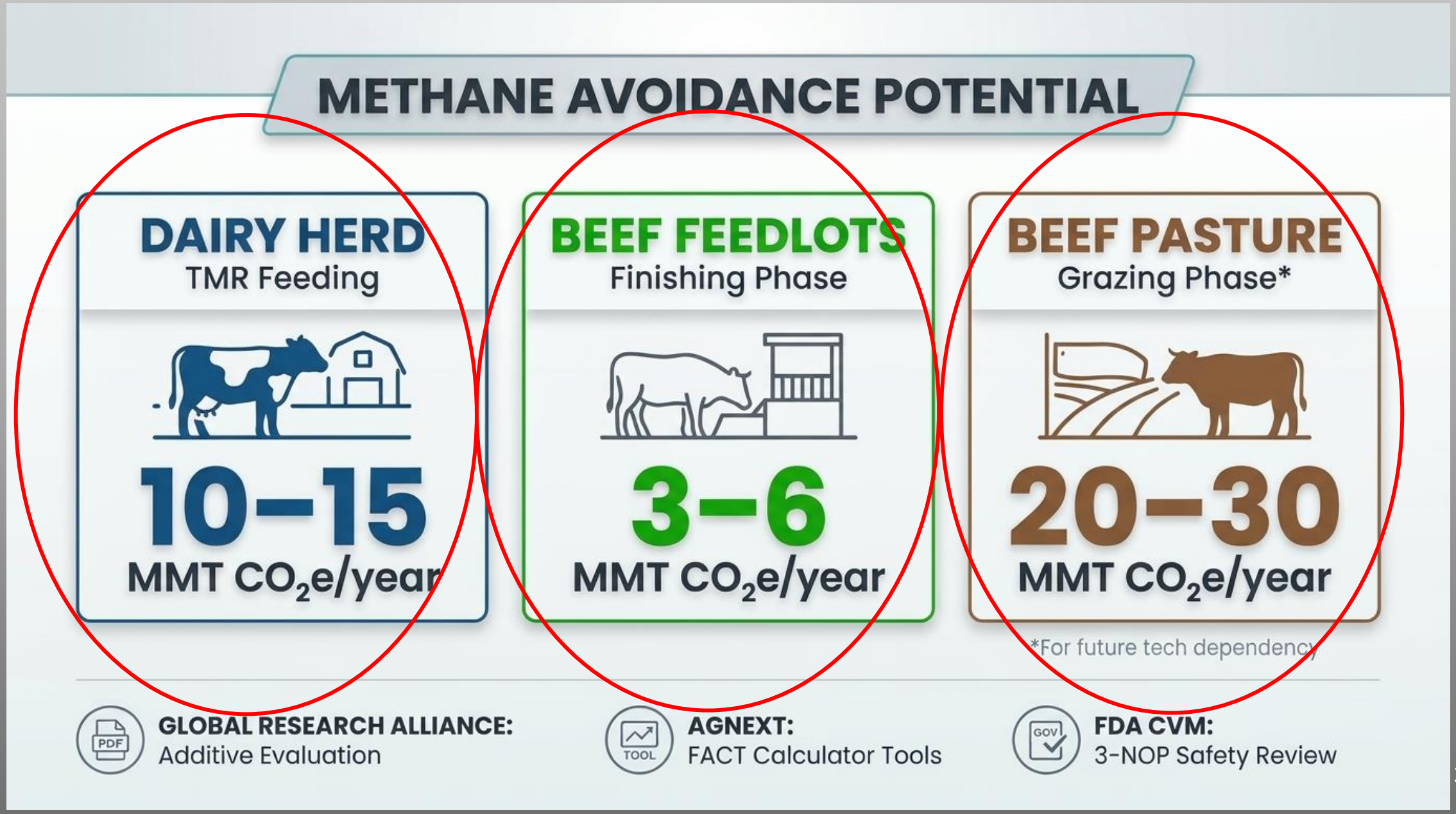
TEXAS A&M AG RENEWABLE Nitrogen Optimization

NM NUSU Precision Fertilizer Trials

USDA SOUTHWEST Climate Hub Data

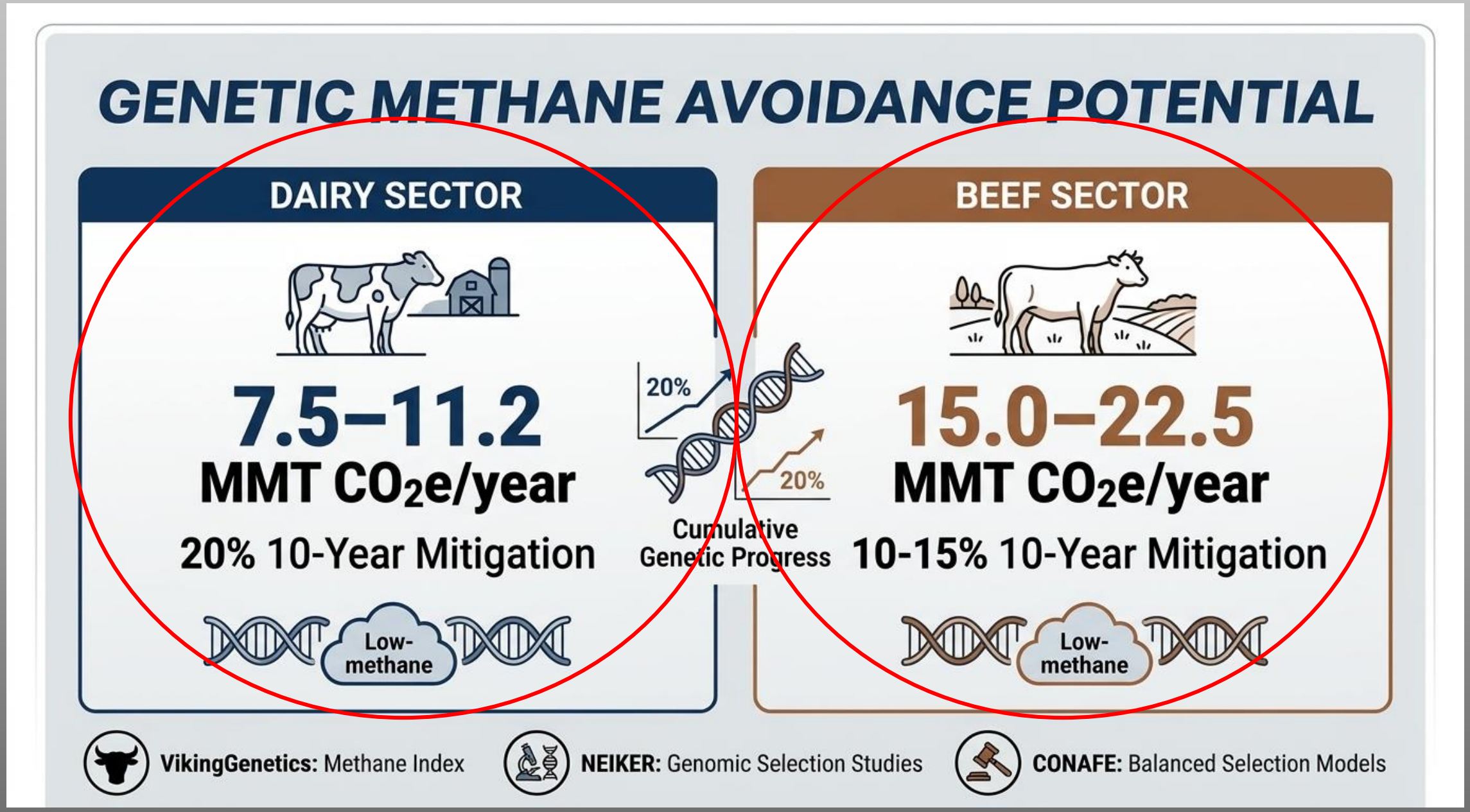
Livestock: recognized management practices to reduce GHG emissions

Methane-Inhibiting Feed Additives



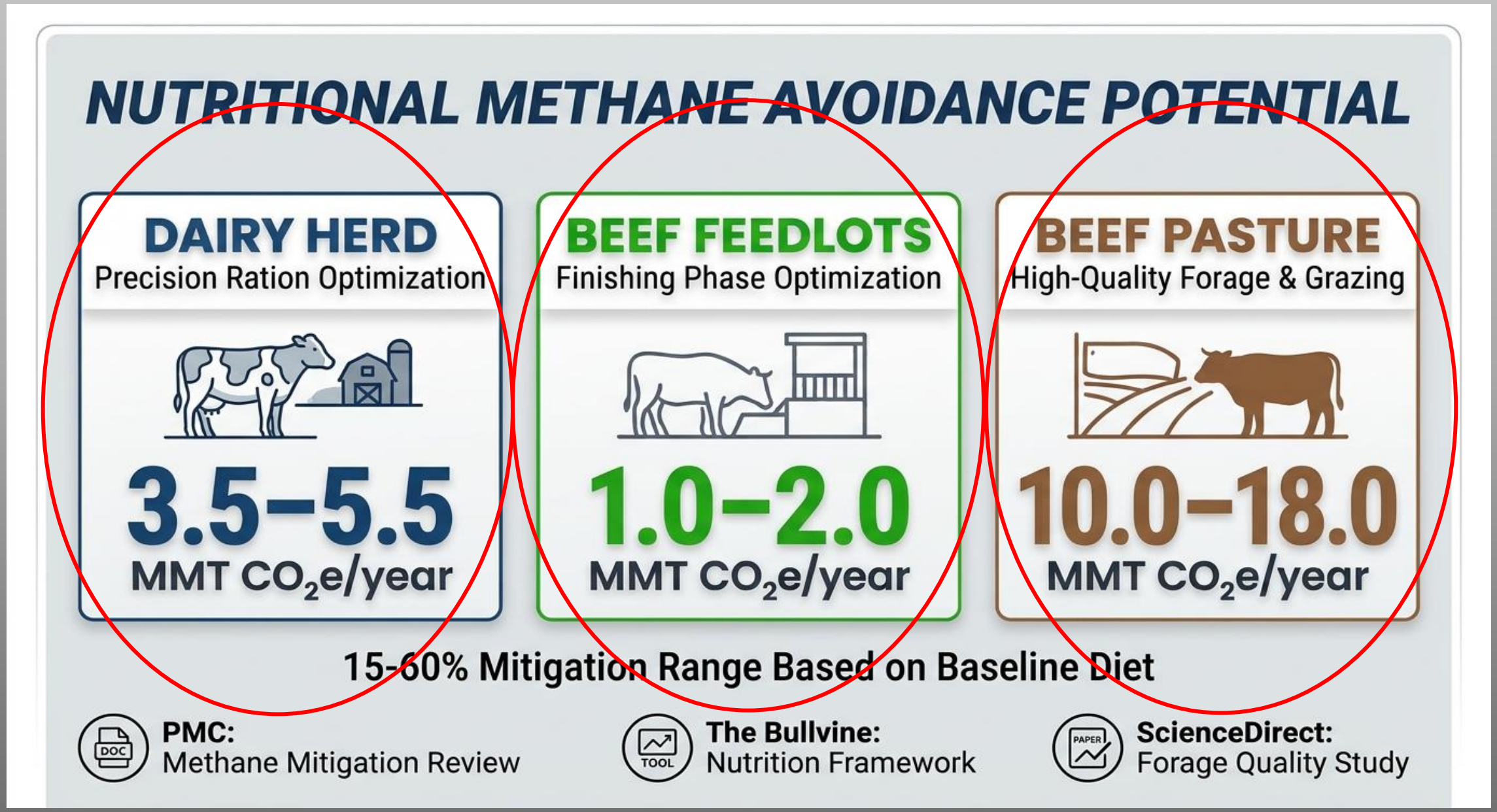
Livestock: recognized management practices to reduce GHG emissions

Genetic Improvement



Livestock: recognized management practices to reduce GHG emissions

High-Quality Forage and Ration Optimization



Manure Management: recognized management practices to reduce GHG emissions

• Anaerobic digesters:

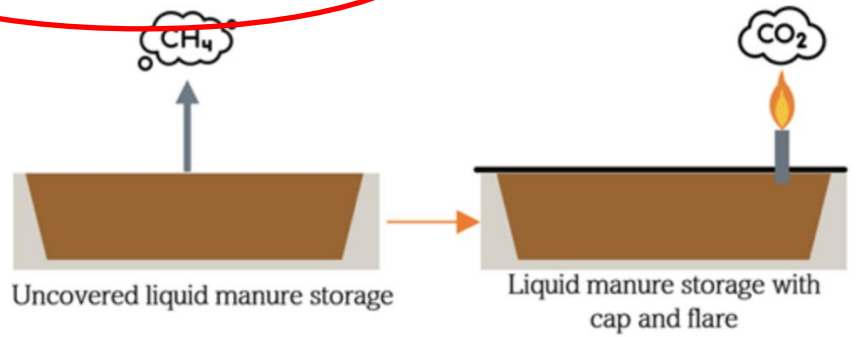


Current Carbon Avoidance: Existing U.S. dairy AD systems currently reduce or avoid between **4.3 to 5.3 million metric tons of CO_2 equivalent (MMT CO_2e) per year**.

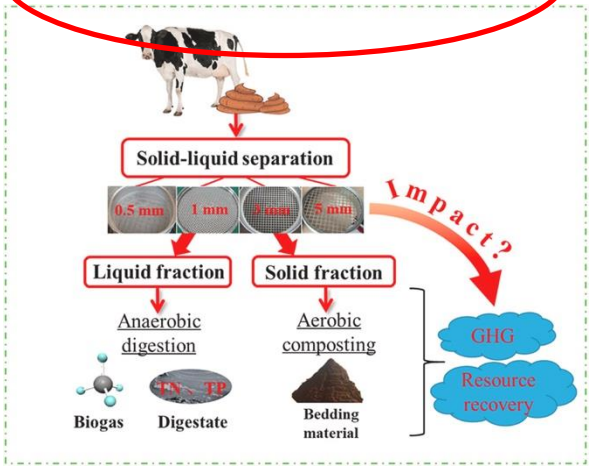
Total Untapped Potential: The EPA AgSTAR program estimates that if AD systems were deployed across the roughly 2,700–2,950 additional large-scale dairy operations capable of supporting them, the total remaining technical potential could avoid an additional **29.9 MMT CO_2e per year**.

• Cover and flare systems:

https://doi.org/10.1021/acs.est.6c08139



• Solid-liquid separation:



Estimated SLS Avoidance Potential: Because the liquid infrastructure is less prevalent overall (<30% of total regional manure management), widespread adoption of solid-liquid separation across New Mexico's liquid-flushed dairies yields a more modest statewide carbon avoidance of roughly **0.15 to 0.35 MMT CO_2e per year**.

https://doi.org/10.1021/acs.est.6c08139

• Shorter (lagoon) storage and composting:



On large Southwestern (SW) dairies (primarily in **Texas and New Mexico**), combining **shorter lagoon storage times** (frequent cleanouts) with **solid composting** can achieve an estimated carbon avoidance of 35% to 55% of the farm's total lagoon methane footprint. For a typical large SW open-lot/flush dairy milking 3,500 to 5,000 cows, this operational shift translates to an avoidance of roughly **3,000 to 7,500 metric tons of \(CO_{2}e\) per farm annually.**
https://doi.org/10.13031/2013.32618

All these potential methane-avoidance strategies may be complementary, but are NOT necessarily additive.

More research is needed here:
Specific to NM Agriculture, Climate, Soils, & Water conditions.

Validate NM-based models, cropping systems, soil-health opportunities, livestock systems (dairy and beef), and manure management practices.

Question:
If GHG reductions are considered a *global public good to society,*
and even mandated in NM (EO 2019-003, net-zero by 2050):
Who will pay for these improvements and investments necessary to achieve these goals?

USDA's Natural Resources Conservation Service (NRCS) may help:

EQIP: help with installation

Environmental Quality Incentives Program
Eligible manure, nutrient and irrigation practices.

Percentage of the selected scenario cost.
Actual farm bills can be higher.

Challenge in New Mexico: funding for many NRCS-approved practices doesn't match the scale of operations in New Mexico.

CSP: annual support

Conservation Stewardship Program
Five-year contracts support existing and added conservation.

NRCS assistance can be combined with compatible CC revenue.

[18] USDA NRCS, New Mexico EQIP
[20] USDA NRCS, 7 CFR 1466.56, credit compatibility

[19] USDA NRCS, Conservation Stewardship Program

New Mexico's CTFS (Clean Transportation Fuel Program) could potentially help producers to trade carbon offsets not only tied to fuel:

- **Direct Revenue Opportunities**
  - **Biogas & Methane Capturing** to generate pipeline RNG+
  - **Biofuel Feedstock Markets:** crop feedstocks for biofuel
  - **Climate-Smart Ag Credits:** credits for on-farm carbon reduction practices (like cover crops, precision fertilizer use, and no-till farming)
  - **Other GHG reduction practices:** NRCS-approved practices, based on NM research, novel technologies, recognition of increased efficiencies as GHG reductions and offsets.

Serious questions remain about Carbon Credit price volatility in relation to the costs of technologies and operations

Looking forward to 2050: another 9% required from Ag: Doable?

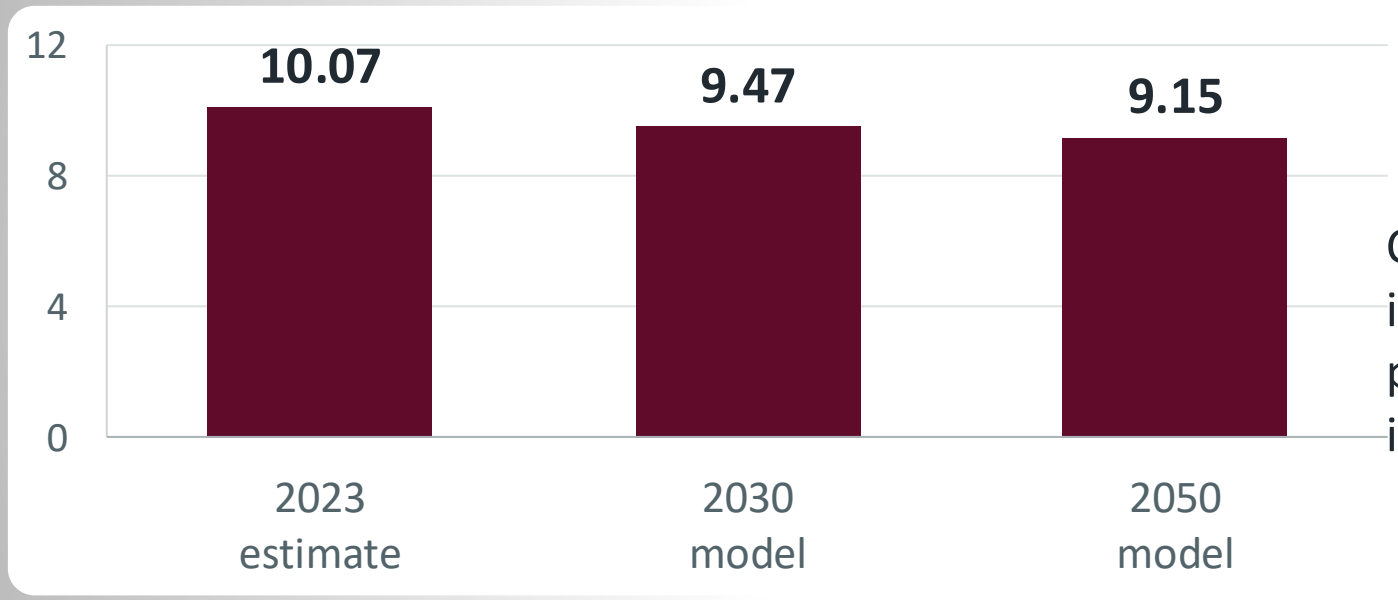
Table 6. Implementation Scenario Emissions by Sector

Sector	Base Year Emissions (2005) ($MMTCO_2e$)	Most Recent Inventory Year Emissions (2023) ($MMTCO_2e$)	Short Term Implementation Scenario Year (2030) ($MMTCO_2e$)	Long-Term Implementation Scenario Year (2050) ($MMTCO_2e$)
Industry	47.72	37.53	23.01	1.66
Transportation	15.85	17.24	12.05	6.31
Agriculture, Forests, and Wilderness	11.15	10.07	9.47	9.15
Electricity Generation	16.33	6.60	4.29	0
Commercial and Residential Buildings	4.07	4.05	3.52	0.07
Waste and Materials Management	1.32	1.05	0.36	0.33
Total	**96.44**	**76.54**	**52.70**	**17.32**

GHG Emission Reduction Measures and Implementation Scenario Projections 27

[2] NM Climate Action Plan (2025), Fig. 5; Tables 6, 47–48

Can agriculture reach the next goalpost? 10% since 2005



2030: 6% additional improvement

2050: 9% additional improvement

Critical: NRCS support, fuel, but more importantly, non-fuel-related carbon credits and possibly other incentives to offset the cost of implementation

[2] NM Climate Action Plan (2025), Fig. 5; Tables 6, 47–48

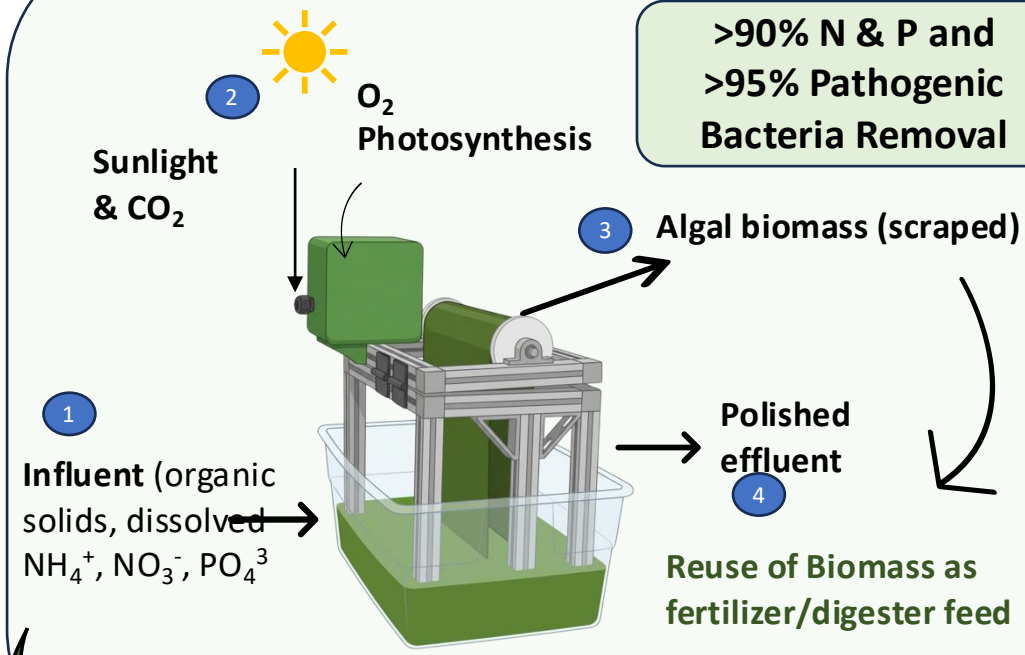
[16] NMED, 20.2.92 NMAC, §§202, 301, 701

[18] USDA NRCS, New Mexico EQIP

Validating Novel & Nature-Based Solutions:

Algae Cultures

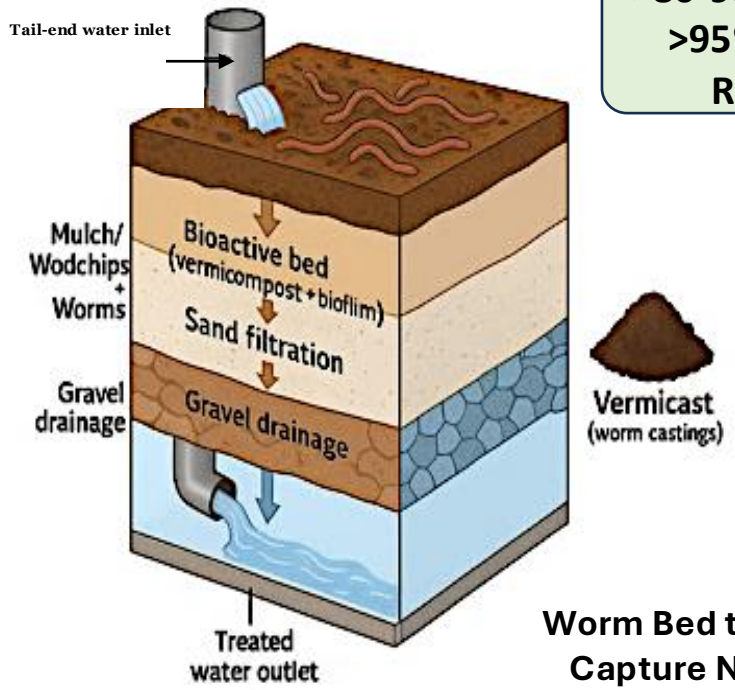
>90% N & P and >95% Pathogenic Bacteria Removal



Algae Reactor System to Capture Nutrients

Worm Beds

>80-90% N & P and >95% Methane Reduction



Worm Bed to Clean Water, Capture Nutrients, and Reduce GHG

NMSU Dairy Extension
Prepared by: Drs. Joyce Marumo; Robert Hagevoort.
Contact: jlm13@nmsu.edu; dairydoc@nmsu.edu

Solid separation or Anaerobic Digestion (AD) *can be added before the algae step. AD can also produce pipeline-quality renewable*



1. Screen/Settle Solids/AD
Remove coarse solids first and protect downstream units.

2. Worm Beds
Reduce solids, organics, & part of the nutrient load.

3. Algae Pond/Reactor
Polish remaining dissolved N and P with algal growth.

4. Reuse/Safer discharge
Recover clearer water and route it for reuse or compliant release.

Vermicompost

Algal biomass

Possible reuses: soil amendment, fertilizer, feed ingredient, or digester input

Validating Novel & Nature-Based Solutions:

Vermiculture: How Worm Power Could Save Water, Reduce Emissions, and Restore Soil Health, converting Livestock Manure into vermicompost and clean water



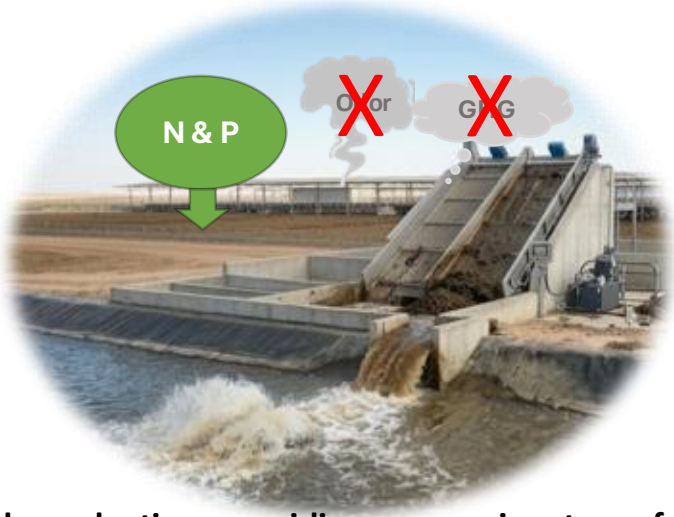


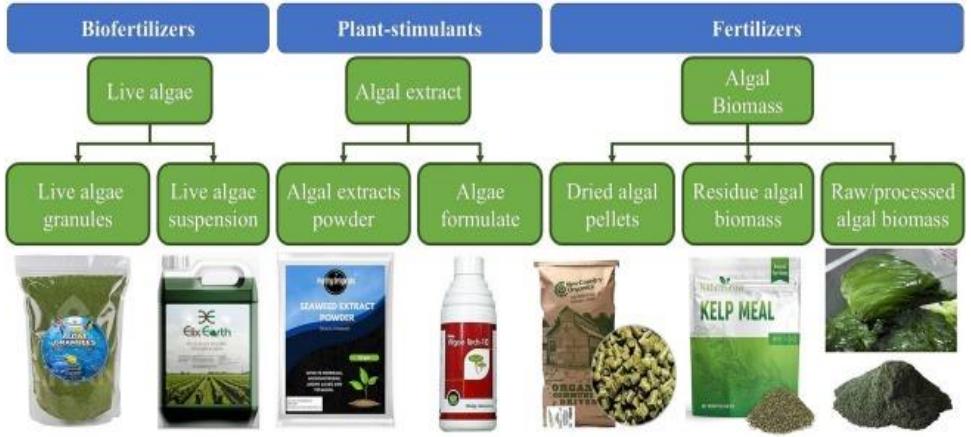




Algae cultures and worm beds capture nutrients (N&P), reduce emissions, and generate valuable by-products (irrigation water, soil amendments, biomass).







Solutions that integrate sustainable (efficient) livestock production, providing economic returns for NM farmers while protecting the environment.